HYDROLOGY

Characterization

The hydrologic characteristics of the South Fork Coos Watershed are controlled by precipitation in the form of rain and are typical of the Coast Range. The Watershed occasionally has snow but the quantity or duration of stay does not produce serious rain on snow events. The climate is characterized by mild, wet winters, and dry summers. Summer temperatures are moderated by marine influence. Average annual precipitation in the Watershed ranges from 50 inches in the eastern headwaters of Williams River to about 85 inches on Coos Ridge, which is the north boundary of South Coos Subwatershed, to about 70 inches at the Watershed mouth (Froehlich *et al.* 1982). The average dry season rainfall (May through September) is 9 to 10 inches for most of the Watershed and tapering to 8 inches at the mouth on the west end of the Watershed and to 6 inches in the eastern headwaters (McNabb *et al.* 1982). About 80% of the precipitation falls from October to March, with half occurring between November and January. June, July and August receive 4% of the annual precipitation. Distribution of annual streamflow is closely related to the distribution of annual precipitation. Thus, high flows occur during the winter months and low flows predominant in the summer. The mean monthly high flows are in February with the low flows in August. Most of the precipitation results in streamflow, with as little as 1 to 2 inches going to groundwater recharge, because the thin, coarse textured soils provide little ground water storage. The lack of ground water storage results in systems that are very responsive to precipitation events.

<u>Tioga Creek Tier I Watershed</u>: The Tioga Creek Subwatershed is a 6th order tributary that combines with Williams River to form the South Fork of the Coos River. It is about 22 miles long draining an area of 24,678 acres. The Tioga Creek gauging station measures the discharge of the upper 61% (15,100 acres) of the Subwatershed.

<u>Other Stream and Weather Monitoring Stations</u>: A stream gage on Priorly Creek measures runnoff from a square mile drainage. The Priorly Creek site also has a rain gage. A RAWS station is located just off the Burnt Mountain Road on the ridge where South Fork Coos, North Fork Coquille and East Fork Coquille Watersheds all meet. The nearest long-term precipitation record (1902 - present) is at the North Bend airport.

Current Conditions

The surface and ground water hydrologic characteristics are dependent on precipitation in the form of rain as is typical of the Coast Range. The South Fork Coos Watershed is very responsive to precipitation events (flashy), due to low permeability and low porosity of the underlying rock, which limits ground water storage.

The Tioga Creek Subwatershed stream gage records show an average annual discharge of 32,608 cubic feet per second (cfs) or 3.78 cfs/square mile/day based on data from the water years 1984 to 1994 (see Figure 1). The mean, high and low daily discharges for each month are shown in Figure2. The mean daily flows range from a high in February of 233 cfs to a low of 2.64 cfs in August. The peak daily flows and low daily flows are equally as variable and range from 1,390 cfs in February to 1.12 cfs in August. The highest daily discharge of record is 6,460 cfs that occurred on February 22, 1986. This was a result of approximately 11 inches of rain in the previous 72 hours. The lowest daily discharge is 0.21 cfs that was recorded October 5th through the 13th, 1987. This resulted from only 3.8 inches of rain in the previous 96 days. These results indicate a direct relationship between discharge and precipitation. A comparison of the percentage of total discharge to total precipitation by month is shown in Figure 3: Tioga Creek Discharge Related to Precipitation. The similar slope and shape of the lines clearly illustrate the strong correlation between discharge and precipitation. This correlation is indicative of

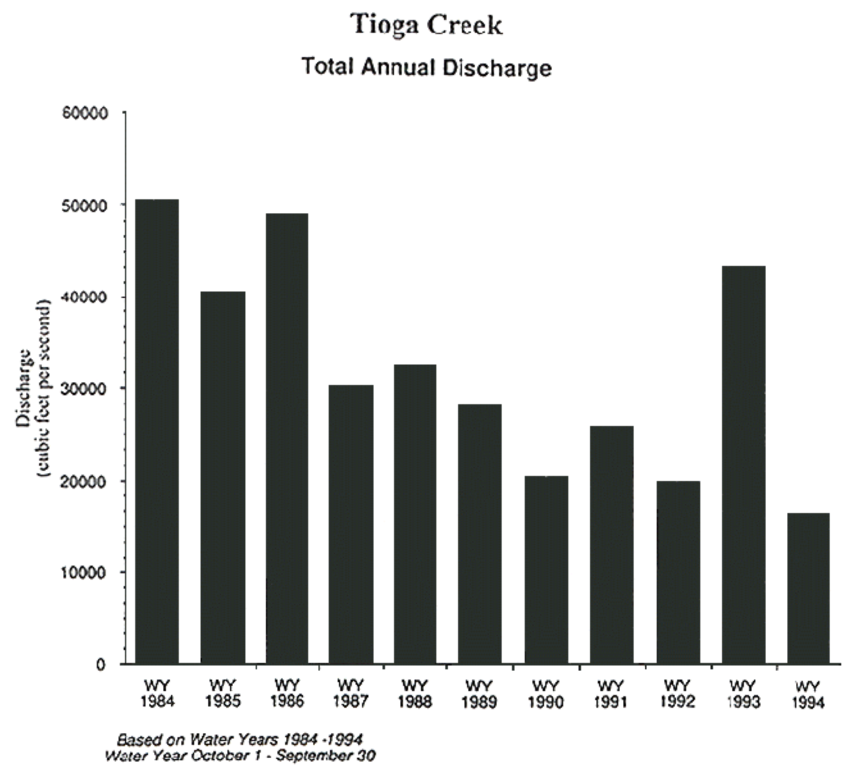

Figure 1

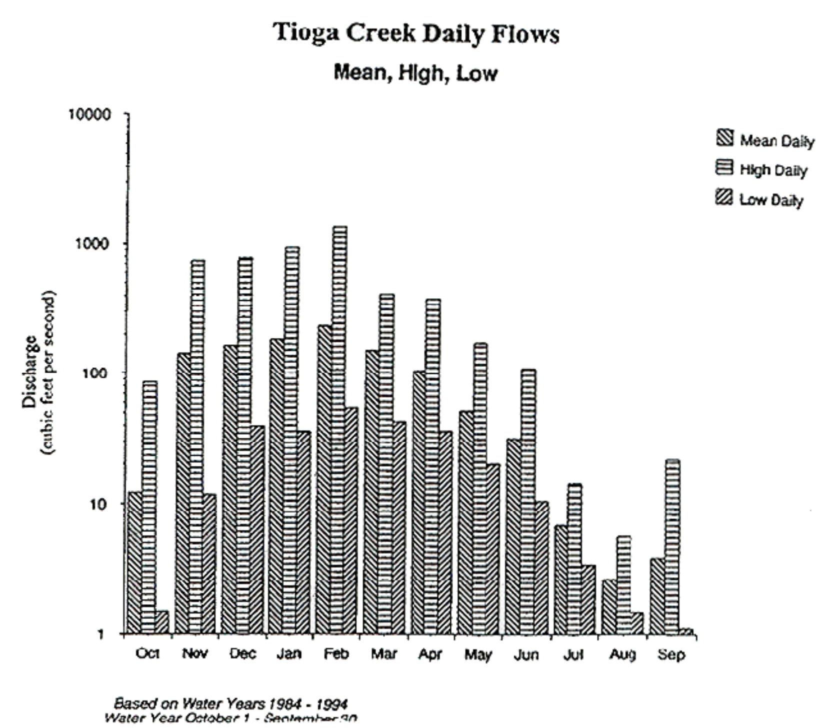

Figure 2

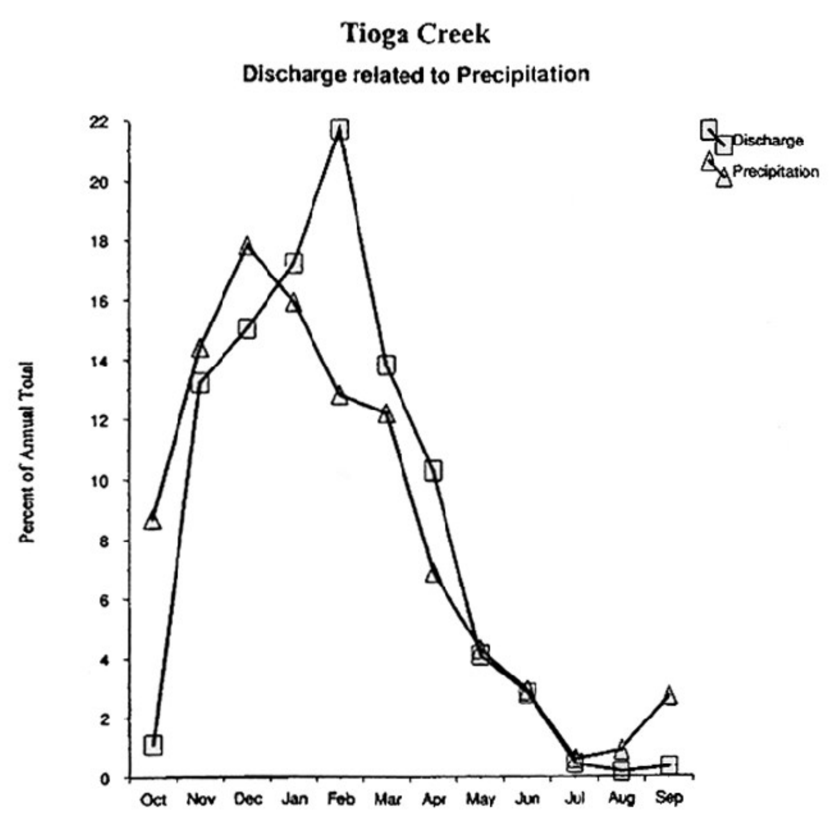

Figure 3

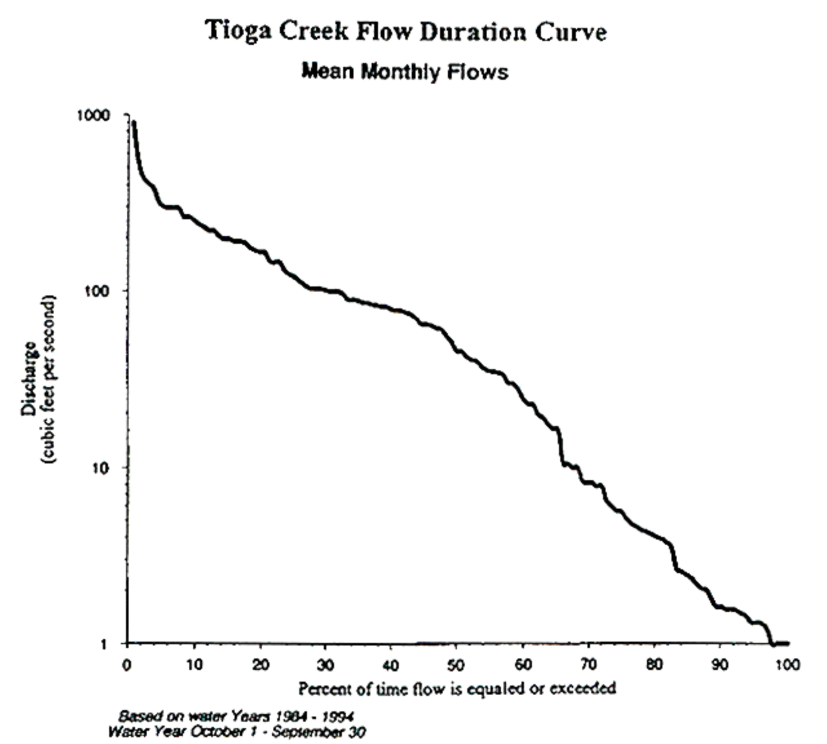

Figure 4

"flashy" systems that have extreme fluctuations in streamflow, storm hydrographs that have short lag times and steep rising and falling limbs, and low ground water storage or recharge capacities. The limited ground water influence is of major importance especially during the summer season when 4% of the precipitation and less than 1% of the discharge occurs and streamflows drop to critical levels. The percentage of the time monthly streamflows are equaled or exceeded is shown in Figure 4: Tioga Creek Flow Duration Curve.

Many of the "headwater" first order streams are formed on coarse textured high permeability soils and dry up as the summer progresses. Streams that originate from seeps and drain fine textured, deep, high porosity soils types have a very low, constant flow, but may have "dry spots" in the channel in later summer. Higher order channels may have pools in late summer, but little live flow. During the summer/fall period, live streamflows are so low they are measured in gallons per minute. Streamflows increase slightly at night, because evapotranspiration demand is at its lowest point.

Reference Condition
The earliest documented flood in the Watershed was in 1861. Little is known about this storm in the Coos River system. However, it was an intense rain on snow event of 12 hour duration in the Coquille system (Dodge 1898, Wooldridge 1971). Summarized accounts in newspapers and letters of the time indicate that this was part of a series of regional scale events that began with heavy snowfall in early November 1861. In western Oregon, this was followed by very heavy rainfall throughout December. Heavy precipitation continued until March 1, 1892. Between 75% and 80% of all livestock in the Northwest either froze to death, or starved, or was lost in the December floods. Many farm houses, most bridges, and whole communities were washed away (Meteorology Committee PNW River Basins Commission 1969).

Mahaffy (1965), in her chronicle of early settlers on Coos River, documents several large floods. Rain fall raised the South Coos 10 feet on November 12, 1885. Warm winds and rain on snow combined with a high tide resulted in the 1890 flood that forced some pioneer families to take refuge on the second floor of their homes. Very heavy rainfall from January 28 to February 3, 1890 affected all of western Oregon. The 7-day totals for the Oregon Coast ranged from 15 to 20 inches of rainfall (Meteorology Committee PNW River Basins Commission 1969).

Mahaffy (1965) reported other major floods on November 23, 1909, December 28, 1945, November 23, 1954, and January 19, 1955. Two storms in rapid succession hit Oregon during November 18 to 24, 1909. During the period, 7-day totals ranged from 10 to 20 inches of rain along the coast with 4 to 6 inch totals for western inland valleys. Twenty-four-hour totals of 3 to 5 inches for December 27/28, 1945 were typical in western Oregon. The November 22 to 24, 1953 (a typo, or possibly reported as 1954 in error by Mahaffy?) affected all of western Oregon. The most intense part of the storm hitting the south coast with 1-day total of 4 to 8 inches and storm totals of 15 to 20 inches recorded (Meteorology Committee PNW River Basins Commission 1969). Other regionally noteworthy storms not reported by Mahaffy occurred in November 1896, October 1950, January 1953, and December 1964 (Meteorology Committee PNW River Basins Commission 1969). Large storms like these do exhibit variation across the affected area. For example, the 1964 storm caused a 50 to 100-year flood event in many watersheds including the South Fork Coquille where it is the flood of record. However, the 1964 flood was not a high magnitude at Millicoma gage station, which was the closest station to the South Fork Coos operating at that time.

There is insufficient monitoring data to establish a comparison between current and historic hydrology and changes from land management. The Tioga Creek gaging station has only a 14 year period of record and much of this period was drier than normal. The Priorly Creek gage measures runoff from a small drainage and is likely not representative of the South Fork Coos Watershed as a whole. The nearest U.S. Geologic Survey (USGS) gaging station with a long period of record (1954-1981) is located on the West Fork of the Millicoma River near Allegheny. Those records indicated a flow with a magnitude of a 10-year return interval occurred in December of 1954. The largest flow ever recorded at that station occurred on November 24, 1960 and was also estimated to have a return interval of approximately 10 years.

Syntheses and Interpretation

Extreme and Frequent Flows: Extreme peak and minimum flows in the low elevation Coast Range are dependant on climatic patterns rather than vegetation manipulation. Following timber harvest, peak flows during fall and spring periods are likely to be increased primarily due to reductions in transpiration and interception losses following harvest (Jackson and Van Haveren 1984 cited in Reiter and Beschta 1995). However, fall and spring peak flows are generally considerably smaller than the larger peak flows that typically occur during large storms in midwinter.

Peak flows after forest management activities have also been a subject of continuing controversy because little evidence exists to determine whether these activities have had an effect on the infrequent peak flows in the precipitation dominated Coast Range. By definition, a peak flow is the instantaneous maximum discharge that is generated by an individual storm. The magnitude of the annual peak flow is highly variable from year to year because of the randomness of precipitation events. A frequency analysis is usually done to establish the relationship between the size of the event and it's return period.

Peak flows are predominantly generated by rainfall events in the Coast Range. In a literature review comparing studies of nine rain-dominated coastal streams, eight showed an increase in peak flows following harvest and one showed a decrease. In over half of these studies winter peak flows increased, and the smaller fall and spring peak flows increased in 8 of the 9 studies. The magnitude of change range from a -36% to a +200% (Reiter and Beschta 1995). These studies considered only small drainages (30-1,000 acres), and did not consider timing and synchronization or desynchronization effects as water routes through larger mainstem streams. These studies did not consider the distribution of harvest units throughout the watershed. In 3 of these studies, the peak flow increases were not statistically significant.

A typical design feature of hydrologic studies in the 1950s, 60s and 70s was to remove all trees in the treated drainage from the ridge top to creek edge. This was in keeping with conventional logging practices of the time, but does not reflect practices on Federal lands since the implementation of the Forest Plan in 1994. Research studies have rarely looked at the effects of clearcut timber harvest where stream buffers are used or at the effects of thinning on streamflows. In a hydrologic study on three small watersheds near Newport Oregon, one 750-acre watershed was treated using three clearcuts averaging 62 acres each while leaving a stream buffer of 50-100 feet on each side of the stream along the main channel. No changes in peak flows were observed, even during fall and spring storms (Hall *et al.* 1987).

Past and present extreme floods (greater than a 20-year return frequency) are the result of natural weather patterns and flashy watershed response. Major channel adjustments have resulted from infrequent extreme flood flows. Forest management has had little to do with increasing the magnitude of these events, as will be explained below. In contrast, frequent flows (those high discharges that return several times each winter season) and the bankfull flows (return period of 1.5-2 years that fills the active channel) are responsible for maintaining channel dimensions and moving most of the sediment load.

Minor increases in the amount of daily flow in the spring and fall may result following harvest activities. This is a result of the younger vegetation transpiring less water and allowing more water to route to the stream channel. This increase is usually considerably less in magnitude than the frequent flows (those flows that occur several times each winter, but are less than the annual high flow) and has little effect on overall flow.

Compacted surfaces including roads, landings and skid trails can permanently increase runoff and yield and advance timing when more than 12% of a watershed is occupied by roads or compacted (Harr 1976). Roads can intercept hillslope subsurface flow and act as extensions of the stream network and route water faster to streams. High ditch flows during very intense storms have been observed along roads with insufficient numbers of cross drains in the Watershed. Under more normal conditions ditch lines carry little water. Not all of this additional water is contributes to stream runoff because some evaporates or is storage via soil detention.

Patterns of existing regeneration harvest may be causing some small increases to fall peak flows, particularly in small tributary drainages. However, larger floods, such as the November 18, 1996 storm, overwhelm any small increase in flow due to removal of forest vegetation and/or present road density levels. Additionally, the first fall peak flows are usually small and geomorphically inconsequential in the Coast Range. The large extreme peak flows, which tend to modify stream channels and transport most of the sediment, are infrequent and typically occur during mid-winter after the soil moisture deficits have been satisfied in both the logged and unlogged watersheds.

<u>Channel Response to Flow</u>: Most of the stream miles in the South Fork Coos Watershed are not sensitive to increases in flow. Steep Rosgen headwater A type channels are static and neither improving nor degrading (Rosgen 1994). Mid-gradient B type channels with rock or LWD control are stable, even with increases in flow. Down valley reaches or occasional flats include low gradient C type channels. These channels will continue to be stable and neither aggrading nor degrading. C channels that have downcut and converted to F type channels, mostly along lower mainstem, will continue to be unstable and provide sediment inputs by bankcutting during large storms.

<u>Annual Yield</u>: Forested areas use large amounts of water to satisfy evapotranspiration demands. In western Oregon, evapotranspiration can exceed 25-inches annually. However, site conditions determine how much evapotranspiration will actually occur, and depends on slope, aspect, soils, type of vegetation and climatic conditions. A 1979 study by Harr and others in western Oregon showed water yield increases averaging 43% (29 cm) during the first five years following clearcutting a small drainage. While the largest absolute increases in yield occurred in the winter, the largest relative increases in water yield occur in the fall and spring. While the yield increases from recently clearcut small headwall basins can be large, their influence on the yield of the larger parent watershed can be overshadowed by the normal water yields from uncut or reforested areas. Estimates of potential water yield increases from large forested watersheds are in the range of 3-6%, assuming the use of 70-100 year rotation intervals (Harr 1983). After examining some 90 watershed studies worldwide, Bosch and Hewlett (1982) determined that water yield increases are usually only detected when at least 20-30% of the watershed has been harvested.

As of 1997, 42% of the BLM lands in the Watershed supported stands 1 to 39-years old. These are hydrologically immature stands, which use water at less than potential transpiration rates. When only the LSR, Riparian Reserves and administrated withdrawn lands are considered, 37.5% of the forest land supports stands younger than 40-years in 1997. The average annual water yield will decline as the BLM stands in reserves and on administratively withdrawn lands reach hydrologic maturity ($\pm$40 years old):

Table Hyd-1: Percent of BLM Reserved and Withdrawn Forest Lands That Have Reached Hydrological Maturity

Year	Acres of stands <40-years-old	percent of forested Reserve and withdrawn lands with stands <40-years old	Percent of the forested reserve and withdrawn lands at or above hydrologic maturity
1997	12,052	37.5%	62.5%
2007	9,262	28.8%	71.2%
2017	5,715	17.8%	82.2%
2027	1,929	6.0%	94.0%
2037	0	0.0%	100.0%

Streamside Stand Retention and Thinning Affects on Water Yield: Much of the research that is the foundation of our understanding of how timber harvest affects water yields was done in the 1950s, 60s, and 70s. These studies typically involved clearcuts and other land treatments that went from ridge top to stream edge. This was in keeping with conventional logging practices of the time, but does not reflect practices on Federal lands since the implementation of the Forest Plan in 1994. Little research has been done in the Pacific Northwest looking at the affects of partial cuts, thinnings, patch cuts, or the affects of clearcutting while retaining streamside buffers on water yields.

In a hydrologic study on three small watersheds near Newport Oregon, one 750-acre watershed was treated using three clearcuts averaging 62 acres each while leaving a stream buffer of 50-100 feet on each side of the stream along the main channel. No changes in peak flows were observed, even during fall and spring storms (Hall *et al.* 1987).

An average annual yield of 2.4 inches was detected for four years after a shelterwood cut, where 50% of the basal area was removed from a southwest Oregon Cascades watershed. A patch cut watershed, which had 20 small clearcuts totaling 30% of the watershed resulted in an average water yield increase of 3.5 inches (Harr *et al.* 1979). Harr and coauthors (1979) noted that the hydrologic changes caused by timber harvest cannot be separated from roads or soil disturbance. Tractor logging resulted in compacted soils on 13% of the shelterwood cut watershed, and on 4.5% of the patch cut watershed (15% of the area inside the logging units). In addition, roads occupied 1.6% of the shelterwood unit and 1.7% of the patch cut watershed.

Huff and others (2000) modeled the changes in water yields in the Sierras resulting from a large-scale thinning and vegetation program aimed at improving fire resilience, providing biofuel, and sustainable generation of other forest products. They concluded the thinning and vegetation management program would, on average, increase water yields about 1%. U.S. Geological Survey considers stream-flow measurements within 5% of the actual value for 95% of the observations to be “excellent,” and considering the variability of annual flows, the expected changes attributable to the projects are unmeasurable. Where individual trees or small groups of trees are harvested, the remaining trees will generally use any increased soil moisture that becomes available following timber harvest. Because of such “edge effects,” partial cuts, like shelterwood cuts and thinnings, are expected to have little effect on annual water yields.

Trees within the Riparian Reserve intercept, and transpire the water in the soil made available by up slope harvest activities in the Matrix. For example, a single mature pine tree in the northern Sierra Nevada depleted soil moisture to a depth of about 6 meters and a distance of 12 meters out from the trunk. This one tree transpired about 88 cubic meters more water than a surrounding logged area. This summer transpiration loss is equivalent to about 180 mm of rain over the affected area (Ziemer 1968). Chen (1991), in his study of edge effects on microclimate patterns, found that edge effect, with respect to soil moisture, was not detectable at distances greater than 197 to 295 feet (distance depended on aspects) into the stand from the stand’s edge against a recent clearcut. This suggests the hydrologic response of a landscape, where Riparian Reserves are employed, may be very different from the response of watersheds denuded from ridge top to creek as part of research projects.

Timing of Flows: Forest management can have an affect on the timing of flows. Flows appear to occur earlier in the fall than in the past. Reduced transpiration from hydrologically immature trees results in increased soil moisture content. As the fall rains occur, less precipitation is needed to saturate these soils and the excess water enters the stream system primarily through subsurface flow. This results in a rise in streams levels earlier in the year than under undisturbed conditions.

In the Coast Range, the response time of streams to storms is "flashy" because of limited soil and groundwater storage. It is thought that roads and clearcuts in a watershed act positively in advancing timing for a particular storm (Jones et. al. 1996). Roads and ditchlines may be acting as extensions of the stream network and channel the precipitation directly into the stream system. Midslope roads could be intercepting subsurface flow moving in a downslope direction. These factors result in a quicker rise of the streamflow followed by a quicker drop than may have happened in the past. Runoff from compacted areas can also advance this timing in the tributary streams, however, compaction in the analysis area is thought to be low.

Minimum Flows: Low flow volumes may initially increase following timber harvest, but the effect is short lived (5-10 years). In addition, the absolute difference in additional quantities of streamflow is small (Harr and Krygier 1972, Hall *et al*. 1987). However, increases in low volumes may be beneficial to fish during the summer when temperatures are high and flows are lowest. This is due to the fact that the water temperature change produced by a given amount of heat (direct solar radiation, longwave radiation, convection and stream bed conduction) is inversely proportional to the volume of water heated, or in other words, the discharge of the stream (Brown 1983). Streamside vegetation left in place through the use of buffer strips can intercept and transpire the additional water in the soil that was available by cutting the upslope stands. Timber harvest can result in a decrease in summer low flow volumes if conifers are replaced by red alders. This is caused by red alder’s greater evapotranspiration rates compared to the conifers they replaced in a watershed (Hicks et al. 1991). The removal of beaver from stream systems has resulted in the reduction in the number of beaver dams. The loss of beaver dams and log jams reduced volume of water stored in pools along the stream channels. These structures release water slowly over the summer and probably supplied cooler water due to thermal stratification in the deeper pools.

Summer flows are a result of subsurface flow being released during the late spring/summer and is primarily dependant upon soil types, soil depths and porosity. Many soil types in the South Fork Coos Watershed are shallow and coarse textured and do not retain much water. The bedrock geology in the Watershed does not favor ground water accumulation.

Trends: Annual yield will decrease and the frequent flows may decrease as young timber stands in the analysis area reach age and become more efficient at transpiring water. Extreme peak and minimum flows are dependant on climatic patterns.

References

Chen, J. 1991. Edge Effects: *Microclimatic Pattern and Biological Responses in Old-Growth Douglas-fir Forest*. Dissertation. Univ. of Wash, Seattle.

Bosch, J.M.; Hewlett, J.D. 1982. *A Review of Catchment Experiments to Determine the Effects of Vegetation Changes on Water Yield and Evapotranspiration.* J. of Hydrology 55:3-23.

Brown, G.W. 1983. *Forestry and Water Quality*. College of Forestry, Oregon State Univ., Corvallis.

Dodge, O. 1898, reprinted1969. *Pioneer History of Coos and Curry Counties*. Reprinted by Coos-Curry Pioneer and Historical Assoc. Western World publishers-printers, Bandon OR. 467 pgs + 103 pg appendix.

Froehlich, H.A.; McNabb, D.H.; Gaweda, F. 1982. *Average Annual Precipitation, 1960-1982 in Southwest Oregon*. EM82:20. Extension Service, Ore State Univ, Corvallis.

Hall, J.D.; Brown, G.W.; Lantz, R.L. 1987. *The Alsea Watershed Study: A Retrospective*, in: Streamside Management: Forestry and Fishery Interactions, Contrib. No. 57. edited by E.O. Salo and T.W. Cundy.. Univ. Wash. Inst. Forest Resources, Univ. of Wash., Seattle.

Harr, R.D. 1976. *Forest Practices and Streamflows in Western Oregon*. USDA, FS Gen Tech Rept PNW-49. PNW Res. Sta., Portland OR.

Harr, R.D. 1983. *Potential for Augmenting Water Yield Through Forest Practices in Western Washington and Western Oregon*. Water Resources Bull. 19(3):383-393.

Harr; R.D.; Krygier, J.T. 1972. *Clearcut Logging and Low Flows in Oregon Coastal Watersheds*. Ore State Univ. For. Res. Lab. Res. Note No. 54, paper 839.

Harr, R.D., R.L. Fredriksen and J. Rothacher. 1979. *Changes in streamflow following timber harvest in southwestern Orego*n. USDA Forest Service. Res. Pap. PNW-249. 22 p.

Hicks, B.J.; Beschta, R.L.; Harr, R.D. 1991. *Long-term Changes in Streamflow Following Logging in Western Oregon and Associated Fisheries Implications.* Water Resources Bull. 27(2):271-226.

Huff, D.D.; Hargrove, B.; Tharp, M.L.; Graham, R. 2000. *Managing Forest for Water Yield The Importance of Scale*. Journal of Forestry. 98(12):15-19.

Jackson, W.L.; Van Havern, B.P. 1984. *Rainfall-runoff Prediction and Effects of Logging: the Oregon Coast Range*. USDI-BLM. Denver Service Center, Denver, CO.

Keppeler, E.T.; Ziemer, R.R. 1990. *Logging Effects on Streamflow - Water Yield and Summer Low Flows at Casper Creek in Northwestern California*. Water Resour. Res. 26(7):1669-1679.

Mahaffy C.L. 1965. *Coos River Echos: A Story of The Coos River Valley*. Interstate Press, Portland, OR.

Meteorology Committee PNW River Basins Commission. 1969. *Climatological Handbook Columbia Basin States, Vol II.*

McNabb, D.H.; Froehlich, H.A.; Gaweda, F. 1982. *Average Dry Season Precipitation in Southwest Oregon*. EM8226. Extension Service, Ore State Univ, Corvallis.

Peterson, E.R.; Powers, A. 1952, reprinted 1977. *A Century of Coos and Curry History of Southwest Oregon*. Coos-Curry Pioneer and Historical Assoc. Caxton Printers, Ltd Caldwell, ID. 599 pgs.

Reiter, M.L; Beschta, R.L. 1995. *Effects of Forest Practices on Water*. In Cumulative Effects of Forest Practices in Oregon: Literature and Synthesis, prepared for Oregon Dept. of Forestry. 185 pgs.

Rosgen, D.L. 1994. A Classification of Natural Rivers. Catena. 22:169-199.

Wooldridge, A.H. 1971. *Pioneers and Incidents of the Upper Coquille Valley*. The Mail Printers, Coquille OR. 385 pgs.

Ziemer, R.R. 1968. Soil Moisture Depletion Patterns Around Scattered Trees. USDA Res. Note PSW-166, Berkeley, CA.

Ziemer, R.R., J.L. Lewis, and E.T. Keppeler. 1996. *Hydrologic consequences of logging second-growth redwood watersheds.* Portland, OR: USDA, Forest Service, Pacific Northwest Region. 5 p.